

# Fresnel coherent diffractive imaging: benefits, implications, and complications

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Lensless imaging with coherent radiation involves a measurement of the scattered intensity and is, in principle, limited in resolution only by the wavelength of the illumination. A natural application of this imaging technique exists within the X-ray community where the wavelength is on the order of typical atomic spacings and whose sources promise increased coherent flux with each new generation. This imaging technique has been demonstrated in both the forward and reflection geometries [1,2], but both variations utilize the same sample illumination conditions and iterative reconstruction techniques.

This technique can be recognized as the inverse problem of recovering a complex wave field from a Nyquist-sampled measurement of the intensity diffracted by a finite object. It is the ill-posed nature of this inverse problem that complicates the recovery of the complex amplitude. Formally, the success of the technique relies on the result that any solution is unique in all but pathological cases[3], while in practice, the measured diffraction contains sufficient uncertainty to render an iterative reconstruction of the object difficult. Traditionally, the recovery techniques have been noted to stagnate and arrive at multiple solutions that match the measured intensity equally well. At the same time, experiments in the X-ray regime typically assume that the incident field is planar and fully coherent across the extent of the sample.

Here, we discuss the benefits that arise from the use of spherically structured illumination of the sample, which gives rise to a Fresnel far-field pattern [4]. We demonstrate that this, in conjunction with a slight alteration of the traditional iterative methods, provides a tremendous increase in the effectiveness of the method by presenting the reconstructed wave fields from material and biological samples and the progress of the estimates during their reconstruction. In addition, we demonstrate that the Fresnel variation of diffractive imaging displays a surprising resilience to low coherence illumination [5] and explore the experimental complications arising from the creation of a structured sample illumination.

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